Plotting the future of the WDS

William I. Hartkopf

Citation: AIP Conf. Proc. **1452**, 80 (2012); doi: 10.1063/1.4718589
View online: http://dx.doi.org/10.1063/1.4718589
View Table of Contents: http://proceedings.aip.org/dbt/dbt.jsp?KEY=APCPCS&Volume=1452&Issue=1
Published by the American Institute of Physics.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2012		**00-00-2012 to 00-00-2012**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Plotting the future of the WDS	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **United States Naval Observatory,3450 Massachusetts Avenue, N.W.,Washington,DC,20392**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
AIP Conf. Proc. 1452, 80 (2012); doi: 10.1063/1.4718589

14. ABSTRACT

The Washington Double Star Catalog (WDS) and its predecessors have served the double star community for over a century; the current catalog now includes over 800,000 measures of nearly 115,000 pairs and is updated on a nightly basis. Large interferometric and CCD surveys, as well as recent catalogs such as 2MASS SDSS, UCAC, etc. have provided much new data for the WDS, but have also highlighted limitations to the current format of the catalog. Multi-wavelength photometry is limited due to a lack of space for filter information. Arcminute?precise WDS designations are proving inadequate to handle binary discoveries in dense fields. Designations for complex hierarchical systems are also proving to be a problem. The Durchmusterung catalogs used for over a century as the primary cross-reference are inadequate for fainter pairs. Astrometric and occultation pairs are not included in the catalog at all. These and other problems will only be exacerbated by massive future surveys such as Gaia. Some of these issues are illustrated and a few possible solutions presented. It is hoped that discussions can be initiated with users of all the USNO double star catalogs concerning ways to expand the information contained in them, in order to increase their usefulness to the entire double star community.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**9**	

Plotting the Future of the WDS

William I. Hartkopf

United States Naval Observatory
3450 Massachusetts Ave., NW, Washington, DC 20392-5420

Abstract.
The Washington Double Star Catalog (WDS) and its predecessors have served the double star community for over a century; the current catalog now includes over 800,000 measures of nearly 115,000 pairs and is updated on a nightly basis.

Large interferometric and CCD surveys, as well as recent catalogs such as 2MASS, SDSS, UCAC, etc. have provided much new data for the WDS, but have also highlighted limitations to the current format of the catalog. Multi-wavelength photometry is limited due to a lack of space for filter information. Arcminute–precise WDS designations are proving inadequate to handle binary discoveries in dense fields. Designations for complex hierarchical systems are also proving to be a problem. The Durchmusterung catalogs used for over a century as the primary cross-reference are inadequate for fainter pairs. Astrometric and occultation pairs are not included in the catalog at all. These and other problems will only be exacerbated by massive future surveys such as Gaia.

Some of these issues are illustrated and a few possible solutions presented. It is hoped that discussions can be initiated with users of all the USNO double star catalogs concerning ways to expand the information contained in them, in order to increase their usefulness to the entire double star community.

Keywords: binaries: catalogs
PACS: 97

A BRIEF HISTORY OF THE WDS

Any discussion of the future of the Washington Double Star Catalog must begin with its past. The WDS can trace its lineage back to Sherburn W. Burnham's magnum opus, his *A General Catalogue of Double Stars within 121° of the North Pole* (1906), usually referred to as the "Burnham Double Star Catalog", or BDS. The BDS was the result of over 30 years' work by Burnham, compiling double star observations scattered throughout the literature and making his own followup observations of many of these pairs. After the catalog's publication, Burnham continued to maintain his database, with the intention of publishing a second edition. In 1912, he gave all his data to Eric Doolittle of Flower Observatory, who further updated the database, but died in 1920 before that new edition could be published. The materials were then passed along to Robert Grant Aitken at Lick Observatory, who in 1932 published his *New General Catalogue of Double Stars* (a.k.a., the "Aitken Double Star Catalog", or ADS).

During this same period, Robert Innes (Union Observatory, South Africa) compiled his own catalog of pairs south of −19° (the *Southern Double Star Catalogue*, or SDS). In the 1950's these materials were also sent to Lick Observatory, where they were

International Workshop: Binaries Inside and Outside the Local Interstellar Bubble
AIP Conf. Proc. 1452, 80-86 (2012); doi: 10.1063/1.4718589

merged by Hamilton Jeffers, Willem van den Bos, and Frances Greeby to create the *Index Catalogue of Visual Double Stars, 1961.0* (or IDS).

That same year a young Lick observer named Charles Worley moved to the U.S. Naval Observatory, and a few years later he arranged that all the IDS materials (some 179,000 computer punch cards) be sent to the USNO as well. A printed edition of the new *Washington Double Star Catalog* was published in 1984 by Worley and Geoff Douglass, with a later edition in 1996 ([1]). After Worley's death, Brian Mason, Gary Wycoff, and the author took over maintainance of the database (c.f., [2]; all USNO double star catalogs are now maintained by Mason and Hartkopf). Figure 1 illustrates the considerable growth of the WDS database from 1906 to the present.

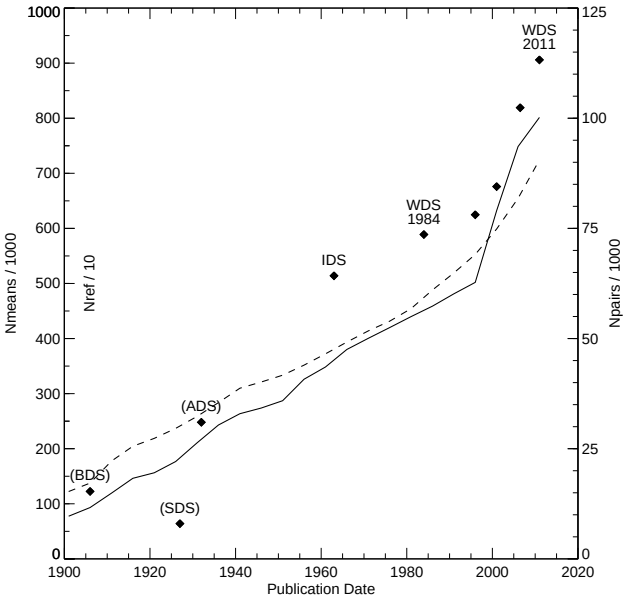

FIGURE 1. Growth of the WDS database from 1906 to the present. Diamonds (right axis) indicate the number of pairs in the database as different editions were published (the earliest catalogs are bracketed with parentheses, as they were not all-sky). WDS 1996, 2001, and 2006 editions are plotted but not labelled. The solid line indicates the number of mean measures, the dashed line the number of publications from which data were extracted (left axis).

WDS: A VICTIM OF ITS OWN SUCCESS?

Much has changed during the past century! Duplicity surveys have expanded greatly in scope, reaching much fainter magnitudes. High resolution surveys, using speckle interferometry, adaptive optics, and now long-baseline interferometry, have discovered many close pairs hitherto unresolvable. Infrared techniques, from IR speckle to 2MASS and other large surveys, have also seen considerable success. As a result, we find ourselves running into a number of limitations due to the current format of the WDS.

We have purposefully been slow to make changes, as we realize that the current catalog is used by many different groups (e.g., the Strasbourg Data Center) and that any changes will force others to modify existing programs. Still, some changes are needed,

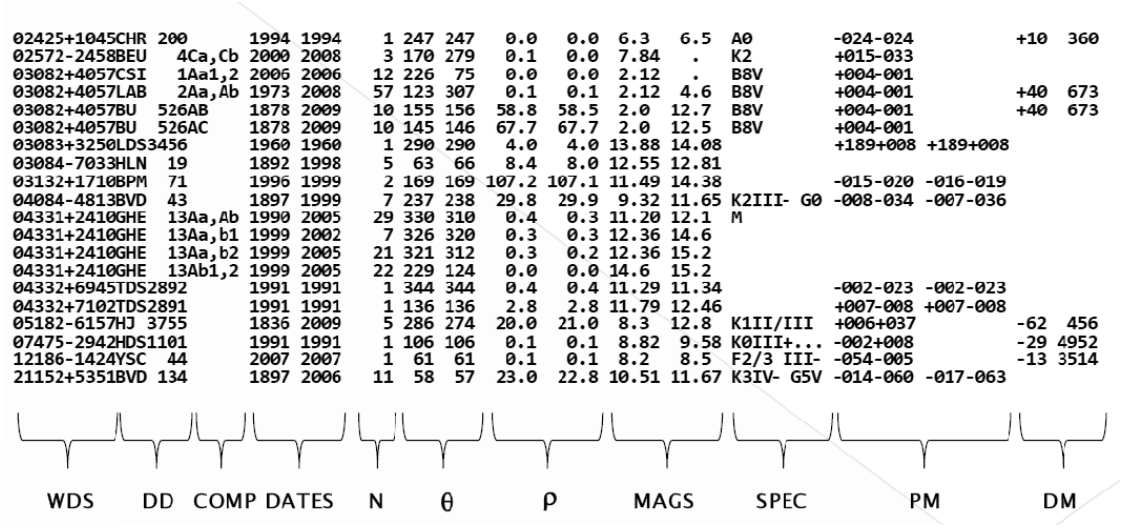

FIGURE 2. Sample portion of the WDS summary catalog. See text for explanation of columns.

so we wish to get input from our “clients" as to the best changes to make and the best way to implement them.

A sample portion of the WDS summary catalog in shown in Figure 2. Columns here include the WDS designation (based on arcminute–precise epoch-2000 coordinates), discoverer designation, components (a blank indicates a simple AB binary), dates of first and last observation, number of observations, first and last value of position angle (θ), first and last values of separation (ρ), primary and secondary magnitudes, spectral classifications, proper motions of both components in mas/year, and a Durchmusterung (BD, CD, CPD) catalog name as a cross reference. (Not shown are additional columns for various note flags, as well as $0''.1$ precise epoch-2000 coordinates for each pair within a system).

Some of the limitations to the catalog are immediately apparent:

- **Components:** Discoveries of close pairs by high-resolution techniques have yielded some complex hierarchical multiple systems (for example, an “A" component resolved into close “Aa" and “Ab" components, then the “Aa" component further resolved into “Aa1" and “Aa2"). The five spaces now available are insufficient for component descriptors such as “Aa,Ab1" or “Aa1,Aa2". Addition of a few extra spaces easily solves this problem.
- **Separations:** Separations in the WDS now range from a few milliarcseconds to several degrees. Additional space and/or flags to indicate arcminute / milliarcsecond / microarcsecond separations will solve this problem as well.
- **Spectral types:** This field is insufficient for listing complicated spectral types for all components. The obvious solution again is more space. However, the WDS is not a spectral catalog, so given the amount of work which would be needed the addition of spectral information is of rather low priority.
- **Cross references:** The Durchmusterung catalogs have served as a useful cross

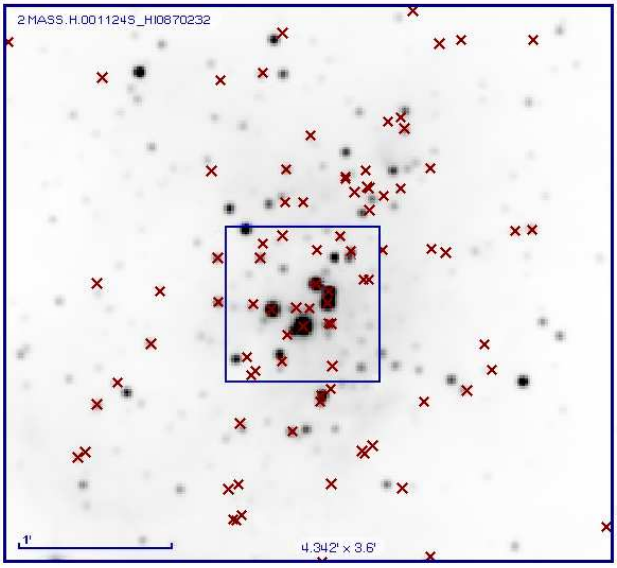

FIGURE 3. Aladin image of a small portion of the Orion Nebula, highlighting the limitations of the current WDS designation scheme. “X" symbols indicate the locations of binaries found during various duplicity surveys, while the square near the center of the field encloses a $1' \times 1'$ portion of the nebula. The current WDS designation is only able to accomodate a single system within each such square.

reference in astronomy for well over a century. However, many new pairs are fainter than the DM magnitude limits. Also, modern precise coordinates for many DM objects are not available. Possible successors may include:

- ⋆ Tycho? These are available for ∼75–80% of objects in the catalog — a better choice than BD/CD/CPD, but probably not sufficient by itself.
- ⋆ UCAC4? This soon-to-be-released successor to the *Third USNO CCD Astrograph Catalog* will match perhaps 90–95% of the catalog. The UCAC catalogs are not well-known within the double star community, but should that be a factor?
- ⋆ NOMAD? The *Naval Observatory Merged Astrometric Database* incorporates the best available information from a number of catalogs (Hipparcos, Tycho, UCAC, 2MASS, USNO-B) and would match essentially all objects in the catalog. Again, it is little known within the double star community.
- ⋆ A mixture of various cross references? For example, HIP / TYC / 2MASS / DENIS / etc. could be listed, depending on magnitude.

Should we have cross references for one or both components of each pair? Additional identifiers for the secondaries of very wide pairs may be useful; the disadvantage is a larger, more unwieldy file.

Should cross references be deleted entirely and let the user rely solely on the precise coordinates of the primary of each pair? Alternatively, should a cross reference based on one or more of the above catalogs be removed to a supplemental file?

- **WDS designation:** The above mentioned limitations are essentially format issues, so simple (at least in principle) to address. This is perhaps the biggest problem, as is deals with the published designations for all visual binary and multiple systems. As noted above, the current scheme is based on arcminute-precise coordinates, so it is difficult to accommodate a density of more than one system per square arcminute. We can occasionally “fudge" the designation a little when two pairs happen to fall too close to one another. However, this doesn’t help much in situations such as the one in the field of the Orion Nebula, as shown in Figure 3. Here we have as many as two dozen pairs within a square arcminute box. As the number of surveys for close, faint pairs increases, these situations will become more common.
  One obvious solution is to convert the WDS designation to one based on arcsecond-precise coordinates. For most of its history many WDS pairs were not known to that level (many epoch–1900 arcminute-precise coordinates were precessed to epoch–2000 without proper motion information; as a result many faint pairs were subsequently “lost"). Due to extensive work matching against other catalogs, often using Aladin, arcsecond or better coordinates are now known for 99% of all WDS pairs.
  This solution is not without its drawbacks, however. There is an enormous amount of information currently in publication; a new designation will undoubtedly lead to considerable confusion. (This is also the reason, by the way, why many component designations have not been corrected as further data have become available and additional components discovered.)

IMPROVEMENTS TO THE WDS DATABASE

The discussion above has been concerned with the WDS “summary lines" — the portion of the WDS database published on our website. However, the individual data lines also suffer from space limitations (largely the result of the 80-column limitations of the Hollerith punch cards from which the current database evolved!) Under their current format, there is insufficient space for separations and no space for formal errors in ρ, θ, or magnitudes, or for photometric filter information (other than codes for “blue", “red", or “infrared"). The solution now being considered is to expand the data lines and pattern them after those in the *Fourth Interferometric Catalog* ([3]).

EXPANDING THE WDS TO OTHER BINARY TYPES?

One question posed to the audience of this workshop was whether we should expand the WDS to include other types of binaries not currently cataloged:

- ⋆ Occultation pairs with only vector separations? (a code in the data and summary lines would indicate the vector separation and angle)
- ⋆ Astrometric pairs? (only summary lines would be added, with perhaps the value of the photocentric semi-major axis given in place of the separation)

⋆ Spectroscopic, eclipsing, and other pairs? (also listed only as summary lines with perhaps added columns for orbital period, etc.)

Audience members were unanimous in their opinion that such an expansion should not be undertaken, as it would make the catalog too complicated and could easily overwhelm those who maintain it. (This opinion was met with great relief by the catalog maintainers.)

TWO FINAL PLEAS

Recognizing the limited manpower available for maintaining the USNO double star catalogs, all observers are urged to email us their tables of double star astrometry, photometry, or orbital elements upon publication. This will ensure much more rapid incorporation of results into the appropriate database. Notification of any missing papers (by yourselves or others) is also welcome.

Also, observers are urged to include all necessary supplemental information — coordinates or other identifiers, dates, telescope aperture, filter information — with their published measures. Surprisingly, much of this crucial information is often missing from publications, sometimes rendering the measures themselves of little use to future researchers.

"The debt to our ancestors for the observations they made to our benefit,
we can pay only by doing the same for our ancestors."

Ejnar Hertzsprung, 1961[1]

[1] Hertzsprung is the gentlemen dressed in white, standing next to Kaj Strand.

REFERENCES

1. Worley, C.E. & Douglass, G.G. 1997, A&AS 125, 523
2. Mason, B.D., Wycoff, G.L., Hartkopf, W.I., Douglass, G.G., & Worley, C.E. 2001, AJ 122, 3466
3. Hartkopf, W.I., Mason, B.D., & McAlister, H.A. 2001, AJ 122, 3408